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Breast cancer incidence by country of birth among immigrant women in British Columbia, Canada

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ABSTRACT

Introduction: Breast cancer rates vary internationally and between immigrant and non-immigrant populations. We describe breast cancer incidence by birth region and country in British Columbia, Canada.
Methods: We linked population-based health and immigration databases for a population with > 1.29 million immigrants to assess breast cancer incidence among immigrant and non-immigrant women. We report age-standardized incidence ratios (SIRs) by birth region and country using non-immigrant women as the standard.
Results: SIRs varied widely by both birth country and region. Low rates were found for South (SIR = 0.52, 95% CI: 0.47,0.59) and East Asian (SIR = 0.75, 95% CI: 0.72,0.79) women and a higher rate for Western Europeans (SIR = 1.15, 95% CI: 1.01,1.30).
Conclusion: There is considerable variation in SIRs across some of British Columbia's largest immigrant populations and several demonstrate significantly different risk profiles compared to non-immigrants. These findings provide unique data to support breast cancer prevention and control.

1. Introduction

Studies of breast and other cancers among migrants can offer insights into cancer etiology. They also contribute data to support cancer prevention and control strategies and may inform women's choices about breast cancer screening. Long-standing research in the United States reported that Japanese Americans had breast cancer incidence rates that were lower than among Caucasian women, but higher than in Japan [1]. These findings suggested that risk profiles of migrant women may acculturate to those of non-immigrants with increased duration in their adopted country. Research into breast cancer patterns among immigrants has expanded considerably since then, with studies having examined incidence in several countries with different historical immigration patterns, and by the specific world region or country of birth of immigrant women [2–6].

British Columbia is Canada's third largest province and has a universal public health care system that provides full coverage for primary care, specialist services (including oncology) and prevention programs such as cancer screening. This province is home to a diverse population of more than 1.29 million foreign-born residents out of a population of 4.65 million, including more than 750,000 immigrants from Asian countries [7]. Breast cancer is the most common malignancy in British Columbia women with 3500 new cases diagnosed annually [8]. The size and diversity of the British Columbia immigrant population present an opportunity to contribute unique data on breast cancer incidence among migrant populations from many different countries, a number of which have not been examined in recent studies. Our study adds to the literature by comparing breast cancer incidence among immigrant women by world region and country of birth to non-immigrants.

2. Methods

2.1. Data sources

This study utilized linked population-based administrative databases from health and other government agencies. A full description of the data sets utilized for this study has been published previously [9]. Briefly, data sets included a provincial health registration file that identifies individuals insured under the public health care system, vital statistics death data, provincial cancer registry data, in-patient and day surgery hospital information, and a national immigration database. Personal identifiers were replaced with study-specific random numbers

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permitting the linkage of data files while protecting confidentiality of all individuals. Research ethics approval was granted prior to data access.

2.2. Cohort derivation and follow-up

The study cohort included all women registered in the provincial health system aged 40 years or older on any date between January 1, 2005 and December 31, 2014. This cohort was originally generated to assess breast screening utilization among immigrant and non-immigrant women and was thus restricted to these ages. Women were excluded if they had a prior breast cancer or mastectomy surgery. We further excluded women not registered in the health system prior to December 31, 2012, as this was the last date for which we could accurately identify immigrant women based on available data.

Birth country was determined from immigration records for all women who immigrated to Canada between 1985 and 2012. Several jurisdictions were pooled into single countries owing to geopolitical events which occurred during the immigration data date range: China, Macau, Hong Kong and Taiwan were pooled into a common "CMHT" group; all countries of the former Soviet Union and the former Yugoslavia remained aggregated as such. We further aggregated countries into world regions consistent with prior Canadian immigrant health studies [6,9]. Within each world region, individual countries with fewer than five incident breast cancers were pooled into an "Other Countries" group.

The date of entry to the cohort was the later of either January 1, 2005 or the date of the woman's fortieth birthday. Person-years at-risk were accrued until the earliest date of any of the following events: breast cancer diagnosis; mastectomy; death; emigration from the province; or end of follow-up (December 31, 2014).

2.3. Study measures

Available demographic variables helped to characterize the study cohort. Age was calculated at the start of follow-up. Postal code of residence was used to assign a census (neighbourhood)-based measure of income status as described elsewhere [6,9]. For immigrant women, duration of time in Canada was calculated as years from the date of landing in the immigration data to the start of follow-up and categorized into four groups (< 5 years, 5–9 years, 10–19 years, ≥ 20 years).

Incident invasive primary breast cancers were obtained from the population-based British Columbia Cancer Registry. We identified cases using International Classification for Diseases of Oncology (3rd edition) [10] site code C50; sarcoma and hematopoietic histologic types were excluded. We calculated breast cancer age-standardized incidence ratios (SIRs) and exact 95% confidence intervals by country and world region of birth using the non-immigrant rates as the standard. The non-immigrant age-specific incidence rates and age-distribution are provided in the study supplemental materials. We further estimated SIRs stratified by duration of time in Canada (< 10 years, ≥ 10 years) and by age.

3. Results

The study cohort included 1,448,572 women of which 260,794 (18.0%) immigrated to Canada between 1985 and 2012. The majority of the immigrant population originated from the East Asia/Pacific (59.4%) and South Asia (13.9%) world regions. Detailed demographic information by region and country of birth is presented in Supplemental Table 1. Briefly, immigrant women were generally younger than non-immigrants. There was considerable variability in the neighbourhood income status of women by birth country. Some groups (e.g. "westernized" countries, Singapore, Japan, South Korea, Iran) showed income quintile distributions similar to, or more favourable than, non-immigrants, however, other groups had a higher percentage of women in the lower quintiles (e.g. Philippines, Vietnam, India, Pakistan). Duration of residence in Canada also differed across populations with some having a very high percentage of women residing in Canada for more than 10 years (e.g. Fiji, Vietnam, Poland), while others showed a much smaller proportion of long-term immigrants (e.g. South Korea, Iran, former USSR).

A total of 26,403 cancers were diagnosed, 2969 (11.2%) among immigrant women. 46 groups had sufficient cases to be presented individually (Table 1). SIRs were elevated for immigrants from Western Europe (SIR = 1.15) and USA (1.21) while women from South Asia (SIR = 0.52), East Asia/Pacific (0.75) and the Caribbean/Latin America (0.80) showed lower SIRs. Within most regions there was heterogeneity in risk by birth country. Several groups within the East Asia/Pacific region had significantly lower SIRs including CMHT (SIR = 0.70), South Korea (0.76), Vietnam (0.37), and Fiji (0.67), however, some of the larger populations within this region showed rates consistent with non-immigrants (e.g. Philippines (0.99), Japan (1.21)). Within the Middle East/North Africa region, immigrants from Egypt demonstrated significantly higher risk (2.75), while the rate among women from Iran, the fifth largest immigrant population in the cohort, was consistent with non-immigrants (SIR = 0.95). Women from the United Kingdom had significantly higher risk (SIR = 1.21). In contrast to the low average SIR for the Caribbean/Latin American region, women from Brazil showed a significantly higher risk compared to non-immigrants (SIR = 2.47). SIRs among immigrants from countries within South Asia were consistently low (e.g. India 0.52, Pakistan 0.61).

Although there was substantial heterogeneity of SIRs by birth country within strata defined by years since immigration, most estimates were not statistically significant. Table 2 presents SIRs by birth region and country, stratified by time since immigration, as well as by age. There were no consistent trends in SIRs across immigrant groups with time since immigration. SIRs for women from India and CMHT suggested significantly lower risk compared to non-immigrants for both recent (< 10 years) and longer-term (≥ 10 years) immigrants. The analysis stratified by age revealed that immigrants from the Philippines and Iran demonstrated significantly higher breast cancer risk in ages 40–49 years compared to non-immigrants (SIRs = 1.21, 1.43 respectively), however, women aged ≥ 70 years showed significantly lower risk (SIRs = 0.34, 0.41 respectively). Immigrants from CMHT and South Korea showed similar risk to non-immigrants at ages 40–49 years, however, significantly lower risks at older ages. Immigrant women from Vietnam and India both had rates significantly lower than among non-immigrants within all age groups.

4. Discussion

To our knowledge this is the first population-based study providing incidence data for numerous specific immigrant populations in Canada. We found considerable variation in SIRs by birth country, which is not observable when data are aggregated at a world region level. The East Asia/Pacific region contained four of British Columbia's most common birth countries for immigrant women, and whilst women from CMHT, Korea and Vietnam demonstrated significantly lower rates compared to non-immigrants, Filipino women showed rates consistent with non-immigrants. Within this region we also observed that immigrant women from Japan and Korea had similar age and income distributions, but markedly different SIRs (1.21 and 0.76 respectively). This study also identified elevated risks for some populations such as Egyptians who have not been included in global comparative incidence monographs to date [11].

Prior studies in Canada and elsewhere have generally shown lower rates of breast cancer among immigrants from South and East Asia [2–6] and have suggested similar or higher rates for immigrants from Western Europe, North America and other western countries [2,4,5]. In Canada, a prior study using surname lists and census populations found breast cancer risk to be 15% lower in Iranian migrants [12], though not

Table 1
Breast cancer age-standardized incidence ratios by country of birth for immigrant women.

World Region	Country	% of Regional Population	Number of Cases	SIR [95% CI]
USA (including Bermuda)	**Regional Rate**	**100.0**	**118**	**1.21* [1.01, 1.45]**
East Asia/Pacific	**Regional Rate**	**100.0**	**1672**	**0.75* [0.72, 0.79]**
	CMHT	60.6	972	0.70* [0.65, 0.74]
	Philippines	18.8	394	0.99 [0.89, 1.09]
	South Korea	7.6	112	0.76* [0.62, 0.91]
	Vietnam	4.2	35	0.37* [0.26, 0.51]
	Japan	2.6	50	1.21 [0.90, 1.60]
	Fiji	1.9	34	0.67* [0.47, 0.94]
	Malaysia	1.2	27	0.89 [0.59, 1.29]
	Singapore	0.8	21	1.16 [0.72, 1.77]
	Indonesia	0.6	16	1.15 [0.66, 1.87]
	Thailand	0.6	6	0.64 [0.23, 1.38]
	Other Regional Country	0.9	5	0.24* [0.08, 0.55]
South Asia	**Regional Rate**	**100.0**	**313**	**0.52* [0.47, 0.59]**
	India	89.0	282	0.52* [0.46, 0.58]
	Pakistan	6.1	19	0.61* [0.37, 0.96]
	Sri Lanka	3.2	9	0.56 [0.26, 1.06]
	Other Regional Country	1.7	3	0.50 [0.10, 1.46]
Caribbean/Latin America	**Regional Rate**	**100.0**	**93**	**0.80* [0.65, 0.98]**
	Mexico	20.6	14	0.73 [0.40, 1.22]
	El Salvador	15.0	17	0.79 [0.46, 1.26]
	Peru	7.8	7	0.74 [0.30, 1.53]
	Brazil	6.8	16	2.47* [1.41, 4.00]
	Jamaica	3.7	5	1.09 [0.35, 2.54]
	Argentina	3.4	5	1.22 [0.40, 2.85]
	Other Regional Country	42.6	29	0.57* [0.38, 0.82]
Middle East/North Africa	**Regional Rate**	**100.0**	**161**	**1.02 [0.87, 1.19]**
	Iran	75.2	119	0.95 [0.79, 1.14]
	Iraq	8.2	6	0.58 [0.21, 1.26]
	Egypt	3.3	14	2.75* [1.51, 4.62]
	Israel	2.3	6	1.76 [0.65, 3.84]
	Other Regional Country	11.1	16	1.15 [0.65, 1.86]
Eastern Europe/Central Asia	**Regional Rate**	**100.0**	**245**	**0.99 [0.87, 1.12]**
	Former USSR State	30.4	71	0.98 [0.77, 1.24]
	Former Yugoslavia	17.9	49	1.01 [0.75, 1.34]
	Poland	17.2	41	0.83 [0.59, 1.12]
	Romania	12.7	39	1.37 [0.98, 1.88]
	Czech/Slovak Republics	7.0	7	0.45* [0.18, 0.93]
	Afghanistan	5.6	13	0.93 [0.50, 1.60]
	Hungary	3.5	9	1.05 [0.48, 2.00]
	Bulgaria	2.9	8	1.35 [0.58, 2.66]
	Other Regional Country	2.8	8	1.48 [0.64, 2.91]
Australia/New Zealand	**Regional Rate**	**100.0**	**19**	**1.29 [0.78, 2.02]**
	Australia	66.1	11	1.20 [0.60, 2.14]
	New Zealand	33.9	8	1.44 [0.62, 2.85]
Sub-Saharan Africa	**Regional Rate**	**100.0**	**97**	**1.11 [0.90, 1.36]**
	South Africa	42.0	53	1.31 [0.98, 1.72]
	Kenya	10.8	19	1.68* [1.01, 2.62]
	Ethiopia	9.3	5	0.85 [0.28, 1.99]
	Tanzania	4.6	6	0.99 [0.36, 2.16]
	Other Regional Country	33.4	14	0.59* [0.32, 0.99]
Western Europe	**Regional Rate**	**100.0**	**251**	**1.15* [1.01, 1.30]**
	United Kingdom	55.3	145	1.21* [1.02, 1.42]
	Germany	18.9	49	1.12 [0.83, 1.48]
	Netherlands	4.3	10	1.06 [0.51, 1.96]
	Switzerland	4.2	9	0.90 [0.41, 1.71]
	France	3.7	6	1.01 [0.37, 2.20]
	Ireland	2.8	6	0.96 [0.35, 2.09]
	Austria	1.4	5	1.60 [0.52, 3.72]
	Belgium	0.9	5	2.92 [0.95, 6.81]
	Other Regional Country	8.5	16	0.84 [0.48, 1.37]

SIR = standardized incidence ratio; CI = confidence interval; CMHT = China, Macau, Hong Kong, Taiwan; USSR = Union of Soviet Socialist Republics; USA = United States of America.
Estimates marked with a '*' denote a statistically significant SIR.

statistically different from the general population. Surname lists have also been used to identify South Asian migrants in the United Kingdom and demonstrate this population's low breast cancer rates [13]. A Canadian study used birth place information captured by the Alberta cancer registry in addition to census populations to demonstrate lower cancer risk among Chinese immigrants [14]. Research in the United States has noted significantly lower breast cancer incidence among Korean immigrants, consistent with our study [15]. It is important to note that differences in the methods used to identify migrant populations may result in the inclusion of different generations of migrants across studies and may have different limitations in their ability to identify migrant populations.

Compared to non-immigrant women of similar age, several populations we examined showed a pattern of elevated risk in ages 40–49

Table 2
Breast cancer standardized incidence ratios and 95% confidence intervals by country of birth and subgroup.

		Years Since Immigration		Age Group		
World Region	Country	< 10 years	10+ years	40-49	50-69	70+
USA (including Bermuda)	**Regional Rate**	**1.16 [0.84,1.58]**	**1.24 [0.98,1.55]**	**1.36 [0.94,1.91]**	**1.13 [0.87,1.44]**	**1.28 [0.78,1.98]**
East Asia/Pacific	**Regional Rate**	**0.80* [0.74,0.87]**	**0.73* [0.69,0.77]**	**1.03 [0.95,1.11]**	**0.73* [0.68,0.79]**	**0.43* [0.37,0.49]**
	CMHT	0.71* [0.63,0.79]	0.69* [0.64,0.74]	0.98 [0.88,1.08]	0.67* [0.61,0.74]	0.45* [0.38,0.52]
	Philippines	1.02 [0.86,1.21]	0.97 [0.86,1.10]	1.21* [1.03,1.41]	1.04 [0.90,1.19]	0.34* [0.22,0.52]
	South Korea	0.90 [0.68,1.16]	0.65* [0.49,0.84]	1.23 [0.95,1.58]	0.55* [0.40,0.74]	0.25* [0.07,0.64]
	Vietnam	0.47 [0.17,1.02]	0.35* [0.24,0.51]	0.56* [0.32,0.91]	0.28* [0.15,0.49]	0.30* [0.12,0.62]
	Japan	1.33 [0.76,2.15]	1.16 [0.80,1.62]	1.45 [0.97,2.09]	1.27 [0.78,1.96]	0.18* [0.01,0.99]
	Fiji	0.70 [0.28,1.43]	0.67* [0.44,0.97]	0.56 [0.21,1.22]	0.81 [0.51,1.21]	0.45 [0.14,1.04]
	Malaysia	0.80 [0.22,2.04]	0.91 [0.57,1.36]	1.53 [0.73,2.81]	0.74 [0.40,1.27]	0.63 [0.17,1.61]
	Singapore	1.66 [0.67,3.42]	1.00 [0.55,1.68]	0.61 [0.13,1.80]	1.47 [0.82,2.43]	0.97 [0.20,2.83]
	Indonesia	1.51 [0.61,3.11]	0.97 [0.44,1.84]	1.11 [0.30,2.85]	1.09 [0.47,2.15]	1.34 [0.37,3.43]
	Thailand	0.53 [0.06,1.93]	0.70 [0.19,1.80]	0.90 [0.24,2.30]	0.45 [0.05,1.61]	NC
	Other Regional Country	0.25 [0.01,1.40]	0.23* [0.06,0.59]	0.17* [0.01,0.93]	0.27* [0.06,0.79]	0.24 [0.01,1.36]
South Asia	**Regional Rate**	**0.48* [0.39,0.58]**	**0.55* [0.48,0.63]**	**0.71* [0.55,0.90]**	**0.57* [0.49,0.66]**	**0.34* [0.26,0.44]**
	India	0.48* [0.39,0.58]	0.54* [0.47,0.63]	0.73* [0.56,0.94]	0.58* [0.49,0.67]	0.31* [0.23,0.40]
	Pakistan	0.57 [0.23,1.17]	0.64 [0.33,1.12]	0.78 [0.29,1.70]	0.37* [0.14,0.81]	0.99 [0.40,2.03]
	Sri Lanka	0.54 [0.11,1.58]	0.57 [0.21,1.24]	0.22 [0.01,1.22]	0.80 [0.29,1.73]	0.50 [0.06,1.80]
	Other Regional Country	NC	1.00 [0.21,2.92]	0.77 [0.09,2.78]	0.35 [0.01,1.94]	NC
Caribbean/Latin America	**Regional Rate**	**1.13 [0.80,1.56]**	**0.67* [0.51,0.87]**	**0.98 [0.69,1.34]**	**0.69* [0.50,0.95]**	**0.76 [0.41,1.27]**
	Mexico	0.92 [0.37,1.90]	0.60 [0.24,1.24]	0.80 [0.32,1.66]	0.84 [0.34,1.73]	NC
	El Salvador	0.94 [0.11,3.39]	0.77 [0.43,1.27]	1.18 [0.48,2.44]	0.68 [0.29,1.35]	0.50 [0.06,1.81]
	Peru	1.33 [0.36,3.42]	0.46 [0.10,1.36]	1.36 [0.37,3.49]	0.68 [0.14,1.98]	NC
	Brazil	2.26 [0.83,4.91]	2.61 [1.25,4.80]	1.88 [0.61,4.38]	2.84* [1.30,5.39]	3.06 [0.37,11.04]
	Jamaica	1.48 [0.18,5.35]	0.92 [0.19,2.70]	2.69 [0.73,6.88]	0.43 [0.01,2.38]	NC
	Argentina	2.87 [0.78,7.35]	0.37 [0.01,2.06]	1.53 [0.19,5.53]	0.95 [0.12,3.43]	1.47 [0.04,8.17]
	Other Regional Country	0.83 [0.43,1.45]	0.47 [0.27,0.76]	0.59 [0.28,1.09]	0.39* [0.19,0.72]	1.11 [0.51,2.11]
Middle East/North Africa	**Regional Rate**	**1.01 [0.79,1.29]**	**1.03 [0.83,1.26]**	**1.42* [1.10,1.82]**	**0.95 [0.76,1.18]**	**0.52* [0.28,0.89]**
	Iran	0.99 [0.74,1.30]	0.92 [0.72,1.17]	1.43* [1.06,1.89]	0.87 [0.67,1.12]	0.41* [0.18,0.81]
	Iraq	0.50 [0.10,1.47]	0.69 [0.14,2.01]	0.62 [0.08,2.25]	0.74 [0.20,1.89]	NC
	Egypt	2.39 [0.65,6.13]	2.93* [1.41,5.39]	3.00 [0.82,7.67]	2.66* [1.07,5.48]	2.69 [0.55,7.85]
	Israel	0.74 [0.02,4.11]	2.44 [0.79,5.70]	NC	2.97 [0.96,6.93]	1.61 [0.04,9.00]
	Other Regional Country	1.51 [0.61,3.11]	0.96 [0.44,1.83]	1.75 [0.84,3.21]	0.80 [0.26,1.87]	0.50 [0.01,2.78]
Eastern Europe/Central Asia	**Regional Rate**	**0.87 [0.68,1.11]**	**1.04 [0.89,1.20]**	**1.20 [0.97,1.46]**	**0.86 [0.71,1.04]**	**0.95 [0.68,1.29]**
	Former USSR State	0.75 [0.49,1.09]	1.21 [0.88,1.63]	0.96 [0.61,1.43]	0.90 [0.61,1.29]	1.18 [0.70,1.87]
	Former Yugoslavia	1.01 [0.52,1.76]	1.01 [0.71,1.40]	1.58* [1.02,2.33]	0.76 [0.45,1.21]	0.66 [0.24,1.45]
	Poland	NC	0.91 [0.65,1.23]	0.86 [0.45,1.51]	0.88 [0.57,1.29]	0.55 [0.15,1.42]
	Romania	1.37 [0.73,2.34]	1.38 [0.90,2.02]	1.94* [1.20,2.97]	0.94 [0.48,1.64]	1.26 [0.46,2.74]
	Czech/Slovak Republics	0.92 [0.19,2.69]	0.33 [0.09,0.84]	0.19 [0.01,1.06]	0.57 [0.19,1.33]	0.66 [0.02,3.68]
	Afghanistan	0.90 [0.33,1.97]	0.96 [0.39,1.98]	1.64 [0.66,3.38]	0.66 [0.21,1.54]	0.48 [0.01,2.68]
	Hungary	0.57 [0.01,3.17]	1.18 [0.51,2.33]	1.16 [0.24,3.39]	0.85 [0.23,2.16]	1.64 [0.20,5.94]
	Bulgaria	1.53 [0.42,3.91]	1.21 [0.33,3.09]	0.43 [0.01,2.39]	1.90 [0.62,4.43]	2.07 [0.25,7.48]
	Other Regional Country	1.22 [0.25,3.57]	1.69 [0.55,3.94]	1.88 [0.51,4.81]	1.29 [0.27,3.76]	1.05 [0.03,5.84]
Australia/New Zealand	**Regional Rate**	**1.26 [0.41,2.94]**	**1.30 [0.71,2.19]**	**0.76 [0.25,1.77]**	**1.75 [0.90,3.06]**	**1.58 [0.19,5.69]**
	Australia	1.50 [0.41,3.84]	1.07 [0.43,2.21]	0.69 [0.14,2.03]	1.74 [0.70,3.58]	1.20 [0.03,6.67]
	New Zealand	0.76 [0.02,4.26]	1.66 [0.67,3.41]	0.88 [0.11,3.18]	1.77 [0.57,4.12]	2.31 [0.06,12.86]
Sub-Saharan Africa	**Regional Rate**	**0.97 [0.64,1.43]**	**1.17 [0.92,1.48]**	**1.22 [0.84,1.71]**	**1.23 [0.92,1.60]**	**0.65 [0.32,1.16]**
	South Africa	1.27 [0.74,2.03]	1.34 [0.94,1.85]	1.72* [1.04,2.69]	1.32 [0.88,1.91]	0.73 [0.27,1.60]
	Kenya	2.60 [0.85,6.08]	1.49 [0.81,2.50]	2.43 [0.89,5.29]	2.04 [1.05,3.56]	0.34 [0.01,1.88]
	Ethiopia	0.82 [0.02,4.59]	0.86 [0.23,2.20]	1.53 [0.50,3.58]	NC	NC
	Tanzania	1.46 [0.04,8.13]	0.93 [0.30,2.18]	1.23 [0.03,6.84]	1.29 [0.35,3.31]	0.47 [0.01,2.61]
	Other Regional Country	0.21* [0.03,0.76]	0.85 [0.44,1.48]	0.21* [0.03,0.76]	0.83 [0.38,1.58]	0.92 [0.19,2.69]
Western Europe	**Regional Rate**	**1.23 [0.97,1.55]**	**1.11 [0.96,1.29]**	**1.28* [1.03,1.58]**	**1.06 [0.87,1.28]**	**1.13 [0.85,1.46]**
	United Kingdom	1.27 [0.93,1.69]	1.19 [0.96,1.44]	1.39* [1.03,1.82]	0.93 [0.69,1.23]	1.50* [1.09,2.01]
	Germany	1.65 [0.96,2.65]	0.96 [0.65,1.35]	1.27 [0.74,2.03]	1.20 [0.78,1.75]	0.69 [0.25,1.51]
	Netherlands	1.08 [0.22,3.17]	1.06 [0.42,2.17]	1.28 [0.35,3.28]	1.37 [0.50,2.99]	NC
	Switzerland	0.44 [0.01,2.44]	1.04 [0.45,2.04]	0.98 [0.20,2.86]	0.92 [0.30,2.15]	0.66 [0.02,3.70]
	France	0.61 [0.02,3.40]	1.16 [0.38,2.71]	0.70 [0.09,2.54]	1.62 [0.44,4.15]	NC
	Ireland	0.90 [0.02,5.02]	0.98 [0.32,2.28]	1.00 [0.12,3.61]	1.22 [0.33,3.12]	NC
	Austria	NC	2.16 [0.70,5.03]	NC	2.45 [0.67,6.27]	1.92 [0.05,10.69]
	Belgium	1.82 [0.05,10.12]	3.44 [0.94,8.81]	4.81 [0.99,14.04]	1.44 [0.04,8.01]	2.55 [0.06,14.19]
	Other Regional Country	0.95 [0.26,2.44]	0.81 [0.42,1.42]	1.06 [0.39,2.30]	0.97 [0.42,1.90]	0.40 [0.05,1.44]

CMHT = China, Macau, Hong Kong, Taiwan; USSR = Union of Soviet Socialist Republics; USA = United States of America; NC = Not calculated due to no breast cancer cases.
Estimates marked with a '*' denote a statistically significant SIR.

years and lower risk in older ages (e.g. Philippines, Iran). Further, in select groups, such as Caribbean/Latin American and East Asian immigrants, the risk in ages 40–49 was not statistically different than among non-immigrants, however, among older women, the SIRs suggested lower risk in these populations compared to non-immigrants. This may relate to differences in risk factor distributions across women in these age groups. For example, if the distribution of reproductive risk factors (e.g. nulliparity, age at first pregnancy or breastfeeding history) among younger women in these populations is different than in the older ages, this may manifest in different cancer risk profiles.

Some of the variation in risk observed in the present study may also result from differences in screening patterns across groups. A prior study of breast screening utilization within our population identified several immigrant groups that screened significantly less than non-immigrants, including South Korea, India, most Eastern European countries, and several other countries within East Asia [9]. Several groups demonstrated significantly higher risk at ages 40–49 years compared to non-immigrants and this may have implications for screening in these populations. In British Columbia, average-risk women are recommended to begin breast screening at age 50, although women aged 40–49 years may elect to without requiring a physician referral. Further research to better quantify risk in this age group for different populations of women may support better informed decisions about the risks and benefits of screening in this age group; it may also enable the development of risk-based screening recommendations based on characteristics beyond simply age and family history of breast cancer.

The strengths of our study include the use of population-based cancer registry data with coverage for an entire province of more than 4.6 million people. Immigrant status was determined by record linkage to national immigration data and included details on country of birth and date of landing in Canada. We were further able to track cohort members in data sets for death, emigration from British Columbia, mastectomy, and cancer diagnosis enabling us to appropriately enumerate a population at-risk for breast cancer.

There are several limitations to our study. The number of incident cancers in several groups was low, leading to statistically imprecise SIRs and requiring aggregation into “Other” groups. Women who immigrated prior to 1985 cannot be distinguished from non-immigrants due to the date range of available immigration data. Further, medical histories are not available prior to immigration to ensure accurate study exclusions for all women. Finally, the cohort was established to examine population breast screening rates and was thus limited to women aged 40 years and over throughout the study follow-up period. As such, the study SIRs presented must be interpreted accordingly. In 2015, 96% of incident breast cancers in British Columbia were diagnosed in women 40 years and older [16] and thus our study does not exclude a significant number of incident cancers.

Our observation of significant variation in SIRs among countries from a common world region suggests there is value in disaggregating data from regional groups into specific birth countries where feasible. Further research utilizing national linkages of cancer registry and immigration data could yield more precise estimates of breast cancer rates by country of birth and improve comparisons across populations. In particular, this may improve the precision in specific subgroups where our study had limited numbers of women. Other research suggests that patterns of breast cancer risk in some populations that are significant source countries for Canadian immigrants are changing [17,18]. These and other studies point to rising breast cancer incidence across several Asian populations in recent years with rates converging to the traditionally higher rates of western countries. Continued research and surveillance of cancer incidence among immigrant populations is warranted. This can improve our understanding of etiology, inform cancer prevention and control strategies, and provide information for women making screening decisions.

Authors contribution

All authors contributed to the conception and design of the study. RW analyzed the study data and drafted the initial manuscript. All authors revised the manuscript critically and approved the final version.

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Disclosures of interest

The authors report no conflicts of interest.

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